PTO 03-2849

CY=JP DATE=19930423 KIND=A
PN=05-101161

ANIMATION GENERATING DEVICE
[Animeshon sakusei sochi]

Masaaki Oka

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. April 2003

Translated by: FLS, Inc.

PUBLICATION COUNTRY	(19):	JP
DOCUMENT NUMBER	(11):	5-101161
DOCUMENT KIND	(12): (13):	A
PUBLICATION DATE	(43):	19930423
PUBLICATION DATE	(45):	
APPLICATION NUMBER	(21):	3-283956
APPLICATION DATE	(22):	19911004
ADDITION TO	(61):	
INTERNATIONAL CLASSIFICATION	(51):	G06F 15/62
DOMESTIC CLASSIFICATION	(52):	
PRIORITY COUNTRY	(33):	
PRIORITY DATE	(32):	
PRIORITY NUMBER	(31):	
INVENTOR	(72):	MASAAKI OKA
APPLICANT	(71):	SONY CORPORATION
TITLE	(54):	ANIMATION GENERATING DEVICE
FOREIGN TITLE	[54A]:	ANIMESHON SAKUSEI SOCHI

[Claims] /2*

[Claim 1] In an animation generating device for generating animation of an object in an environment of physical principles, a minute amount of random-number data is generated and added to the results of a calculation when the motion and change in shape of the object are determined in accordance with physical principles.

[Detailed Description of the Invention]

[0001] [Contents]

The present invention is explained in the following order.

[0002] [Industrial Field of Application]

The present invention relates to an animation generating device and, more specifically, to a device ideally suited to, for example, a three-dimensional special effects device for broadcasting in which animated images of an elastic object such as a "cloth" or a "curtain" are generated so as to indicate movement.

---

*Number in the margin indicates pagination in the foreign text.

[0003] [Prior Art]

When animated images are generated using an animation generating device, a series of animated images are configured one drawing at a time by an animator using the graphic input method so as to define the shapes and changes to the shapes of the images on the screen.

[0004] When animation of a cloth is generated, for example, as shown in FIG 9, the animation generating device [1] has an image converting device [2].

[0005] The image converting device [2] maps and displays the television image on a curved surface. After the original image data [PC1] (here, image data depicting "cloth") for generating the animated images obtained from the original image memory [3] has been changed based on the animation data [D1] obtained from the animation data memory [4], the outputted image data [PC2] of the changes in the image of the cloth are sent to the outputted image memory [5].

[0006] Animation data [D1] are the coordinate values indicating the shape of the cloth at a given instant. If necessary, these consist of one or more frames of data. The animation data are either created manually beforehand by the animator or are generated using calculations involving a simple function.

[0007] [Problem to be Solved by the Invention] If the animated images are generated manually, each frame has to be inputted and the animator has to be disciplined enough to define the shape of each frame. This is a complicated and time-consuming image input method

because it is important for the movement in the animated images to look natural and not artificial.

[0008] In order to solve this problem, there are animation generating devices that run simulations of physical models on a computer to generate animation. In these animation generating devices, the physical characteristics of the object to be animated are modeled and simulated accurately on a computer. This method of determining movement can generate objects simply and easily that resemble animation drawn by hand (Application No. 3-89880, Application No. 3-93392, Application No. 3-93601).

[0009] However, when the movement of an object model generated artificially is simulated and animated against an artificial backdrop or environment in an animation generating device that simulates physical models using a computer, the coordinate values indicating the position and shape of the model are precise values, which result in animation that does not look natural.

[0010] The animation tends to look unnatural. For example, a cloth hanging vertically with respect to the ground remains eternally unperturbed despite the downwards pull of gravity and a curtain remains unwrinkled even when closed.

[0011] In FIG 10 (A) ~ (D), a cloth [NO] hangs vertically a certain distance above the floor [FL]. When there is no wind, the environmental forces are only gravity and the counterforce from the floor [FL]. Even when mass points are subjected to force, it is not

from the surface of the cloth [NO]. As a result, the cloth [NO] remains unperturbed and looks unnatural.

[0012] In FIG 11 (A) ~ (D), a curtain [CO] bunched on one side hangs downward and is moved over a column-shaped object [SO] on the inside of the screen. Because the force of the object [SO] is sustained in the same direction as the bunching, forces is not added towards the outside at the mass points and wrinkles that look natural in three dimensions are difficult to produce.

[0013] Because it looks unnatural, programming has to be done so exact coordinate points are avoided and the cloth [SO] is not positioned, for example, so it completely matches the thrust of gravity. It is extremely difficult to do this type of programming in practice, and so it is difficult to avoid the problems with curtains [CO] described above. This problem has yet to find a satisfactory solution.

[0014] In light of this situation, the present invention provides an animation generating device that easily simulates fine movements and produces natural-looking animated images.

[0015] [Means of Solving the Problem] /3

In other to solve this problem, the present invention is an animation generating device [11] for generating animation of an object [N1, C1] in an environment of physical principles, in which a minute amount of random-number data is generated and added to the results of a calculation when the motion and change in shape of the

object [N1, C1] are determined in accordance with physical principles.

[0016] [Operation]

By adding a minute amount of random-number data to the results of the calculation when determining the movement and change in shape to an object [N1] based on physical principles, fine movement resulting from the larger movement and change in shape can be simulated to generate natural-looking animated images.

[0017] [Working Example]

The following is a detailed description of a working example of the present invention.

[0018] The animation generating device [11] of the present invention shown in FIG 1 has components comparable to those in FIG 9 denoted by the same numbers. The animation data generating device [12] supplies generated animation data [D2] to the animation data memory [4] as animation data [D1].

[0019] The animation data generating device [12] generates three-dimensional coordinate value data as generated animation data [D2] indicating any change in the animated object such as a cloth over time.

[0020] The animation data generating device [12], as shown in FIGs 2 and 3, also supplies environment data [D11] from the environment data memory [21] to the linked equation calculating device [22] indicating, for example, the position of a moving cloth [N1] against the background so that the animated image of the cloth

[N1] takes into account the force of gravity, the strength of the wind, and the shape and position of obstructions.

[0021] The linked equation calculating device [22] performs calculations that solve linked equations for the model of the cloth [N1] relative to the environment data [D11]. The results of the calculations are supplied to the format converting device [23] as three-dimensional coordinate arrangement data [D12].

[0022] The format converting device [23] converts the three-dimensional coordinate data to animation data in a format usable by the image converting device [2] (FIG 1). These are supplied to the animation data memory [4] as generated animation data [D2].

[0023] The linked equation calculating device [22] links the positions of various points on the surface of the cloth [N1] so the mass points [MP] are on the three-dimensional lattice of a spring [SP] to express a three-dimensional model.

[0024] The lattice points (white circles) express mass points [MP] and all the lines between lattice points express the spring [SP]. In the case of a three-dimensional model, a three-dimensional object can be rendered by connecting a single mass point to a maximum of six springs [SP].

[0025] In the case of a planar object, such as a cloth [N1], as shown in FIG 3, a single mass point [MP] is connected to four springs [SP] to express a model of the cloth [N1]. The corner and terminal mass points [MP] are connected to fewer than four springs [SP].

[0026] In the three-dimensional model shown in FIG 3, because a mass point [MP] is mass concentrated at a single point, Newtonian linked equations can be performed. The lengths of the springs [SP] are natural, and the outputted force corresponds to the displacement according to Hooke's Law.

[0027] A hinge expresses the elasticity between adjacent springs. Usually, adjacent springs act on each other to maintain a 90º with respect to each other, and diagonally adjacent hinges act on each other to maintain a 180º with respect to each other.

[0028] In the three-dimensional model shown in FIG 4, the mass points [MP] are calculated in accordance with the following linked equation.

[Equation 1]

$$M \frac{d^2 x}{d t^2} + \Gamma \frac{d x}{d t} = F(x, t) \qquad \cdots\cdots (1)$$

[0029] Here, M is the mass of a mass point [MP], Γ is the decrease coefficient, x are the three-dimensional coordinates expressing the position of a mass point [MP], t is the time, and F is the force acting on the mass point [MP].

In Equation (1), the mass [M] is a constant, and the decrease coefficient added to concentrate the forces is a constant. The force [F] acting on a mass point [MP] is determined by the positions of all of the mass points [MP] and the environment in amounts that change over time.

[0030] In this working example, the linked equation calculating device [22] in FIG 2 uses the following equations to determine the position coordinates of the mass point [MP] solved for in Equation (1). Here, a minute amount of displacement is added to arrive at new position coordinates [xf] for the mass point.

[Equation 2]

$$\text{random0}=\text{uniform\_random}\ (0,\ d) \qquad \ldots\ \ldots\ (2)$$

[Equation 3]

$$\text{random1}=\text{uniform\_random}\ (0,\ d) \qquad \ldots\ \ldots\ (3)$$

[Equation 4]

$$\text{random2}=\text{uniform\_random}\ (0,\ d) \qquad \ldots\ \ldots\ (4)$$

[Equation 5] /4

$$xf=x+(\text{random0},\ \text{random1},\ \text{random2}) \qquad \ldots\ \ldots\ (5)$$

[0031] In Equations (2) ~ (5), uniform_random (a,b) is a function in which a is the average and ±b is a random number selected in a given range. Also, d is a small given number, and xf are the coordinates of the final mass point.

[0032] The linked equation calculating device [22] performs the animation generating method shown in FIG 5 repeatedly during a single processing period to calculate the amount of change in the positions of all of the mass points [MP] (FIG 3) in the cloth [N1] based on the environment data [D1]. The result is animated images of a supple cloth [N1] moving in response to environmental conditions such as gravity and wind force.

[0033] The linked equation calculating device [22] begins the animation generating method at Step SP0 in FIG 5. In Step SP1, a single sample point is selected from the graphic of the cloth [N1] in the original image. A calculation is performed in Step SP2 according to the following equation to derive the force [F] acting on the mass point [MP] of the sample point in accordance with physical principles.

[Equation 6]

$$F=Fs+Fh+Fd+Fg+Fv \quad \text{... ... (6)}$$

[0034] In Step SP3, the linked equation calculating device [22] determines new coordinates for the mass point [MP] of the sample point in accordance with Equation (1). In Step SP4, a minute random-number vector is added to the new coordinates by executing Equations (2) ~ (5).

[0035] After calculating the change in the coordinate position for the sample point, the results of the calculation are stored in the animation data memory [4] as generated animation data [D2].

[0036] In Step SP5, the linked equation calculating device [22] determines whether or not all of the sample points have been processed. If not, the process returns to Step SP1 and the coordinate position of a new sample point is calculated.

[0037] When the coordinate position of all of the sample points in the original image of the cloth [N1] have been calculated for the amount of change, the linked equation calculating device [22] obtains

the results from Step SP5 and the animation generating method is ended in Step SP6.

[0038] When the linked equation calculating device [22] has finished calculating the changes in a single cloth [N1] during a single processing period, it begins the next processing period for the next round of changes.

[0039] As a result, when the animation is of a cloth [N1] falling vertically from a certain height to the floor [FL] where the environmental forces acting on the cloth do not include wind force but take into account the force of gravity and the counterforce from the floor [FL], as shown in FIG 10 (A) through FIG 10 (D), the cloth [N1] falls to the floor [FL] naturally as shown in FIG 6 (A) ~ (D).

[0040] In an animation in which a bunched curtain [C1] hanging vertically is moved over a column-shaped object [SO] from the inside of the screen, as shown in FIG 11 (A) through FIG 11 (D), the curtain [C1] wrinkles naturally even when force to the outside is not added to the mass points sustaining the force of the object [SO] in the same direction as the bunching.

[0041] FIG 8 (A) ~ FIG 8 (D) shows the curtain [C1] in FIG 7 (A) ~ FIG 7 (D) from the X axis. Here, the wrinkles in the curtain [C1] also look natural.

[0042] When graphic animation is generated using this method, the object is expressed in a model consisting of mass points [MP] and springs [SP]. The movement of the mass points [MP] in the object is calculated in accordance with physical principles based on

environmental factors such as wind force and gravity. By adding a minute random-number vector to the new position of each mass point [MP], fine movement can be simulated and a natural-looking animated image is easier to obtain.

[0043] Here, complicated programming and unnatural-looking animated images can be avoided. Natural wrinkles can be generated, and minute displacements can be captured in animated images with subtle variations.

[0044] As a result, the animator does not have to render images by hand, and animated images can be generated automatically that do not bunch up unnaturally.

[0045] In this working example, minute random numbers were added in all directions. However, random numbers can also be added in only a certain number of directions. In the case of a two-dimensional cloth, the displacement along a curved surface looks natural, the amount of minute, localized displacement can be determined, and the amount of displacement can be kept constant in certain directions all by adding minute random numbers.

[0046] In this working example, the object that was animated happened to be a two-dimensional planar object, such as a cloth or curtain. However, the present invention is not limited to this working example. The same results obtain from a three-dimensional /5 spatial object. By positioning the mass points, springs and hinges appropriately, any object desired can be animated.

[0047] [Effect of the Invention]

As explained above, by adding a minute amount of random-number data to the results of the calculation when determining the movement and change in shape to an object based on physical principles, fine movement resulting from the larger movement and change in shape can be simulated to generate natural-looking animated images using the method of the present invention.

[Brief Explanation of the Drawings]

[FIG 1] A block diagram of the animation generating device in a working example of the present invention.

[FIG 2] A detailed block diagram of the animation generating device in FIG 1.

[FIG 3] A grid showing a display model.

[FIG 4] A grid showing a single vector between mass points.

[FIG 5] A flowchart showing the animation generating method executed by the animation generating device in FIG 1.

[FIG 6] Grids showing the animation of a cloth in a working example.

[FIG 7] Grids showing the animation of a curtain in a working example.

[FIG 8] Grids showing the animation of the curtain in FIG 7 from the X axis direction.

[FIG 9] A block diagram showing an animation generating device of the prior art.

[FIG 10] Grids showing animation images of the prior art.

[FIG 11] Grids showing animation images of the prior art.

[Key to the Drawings]

1, 11 ... animation generating devices

2 ... image converting device

3 ... original image memory

4 ... animation data memory

12 ... animation data generating device

21 ... environment data memory

22 ... linked equation calculating device

23 ... format converting device

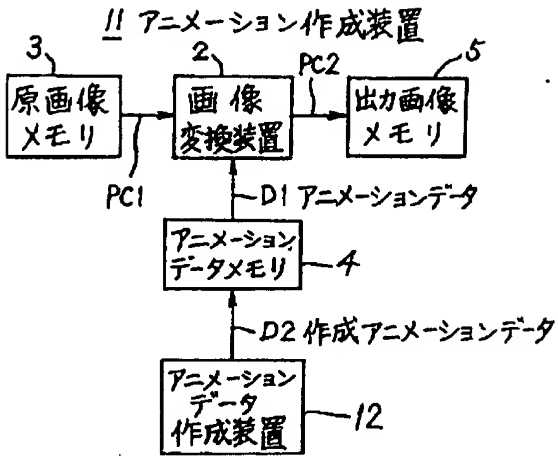


Figure 1

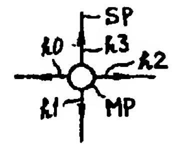
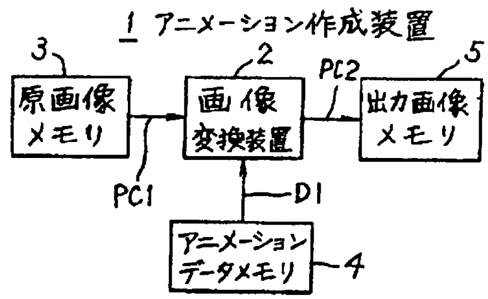


Figure 4

Figure 9



[FIG 1] FIG 1: Configuration of a Working Example
2 ... image converting device
3 ... original image memory
4 ... animation data memory
5 ... outputted image memory
11 ... animation generating devices
12 ... animation data generating device
D1 ... animation data
D2 ... generated animation data

[FIG 4] FIG 4: Display Model

[FIG 9] FIG 9: Configuration of the Prior Art

1 ... animation generating devices
2 ... image converting device
3 ... original image memory
4 ... animation data memory
5 ... outputted image memory

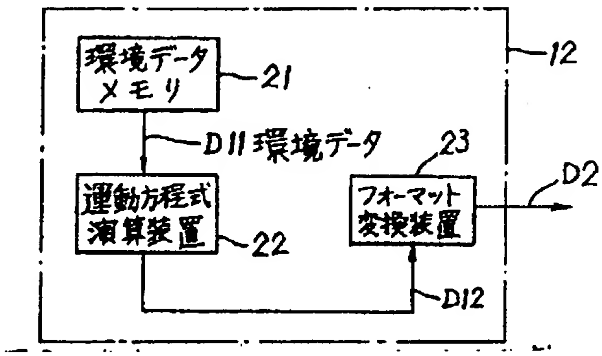
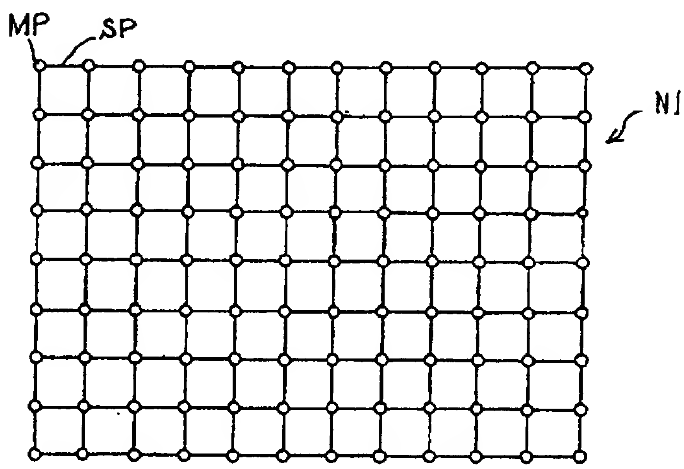


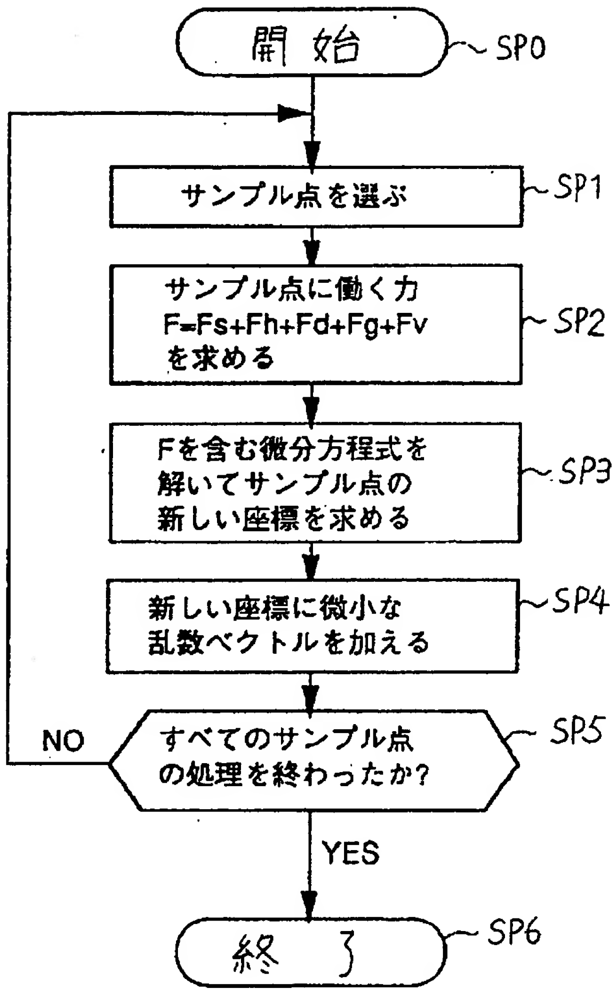
Figure 2

Figure 3

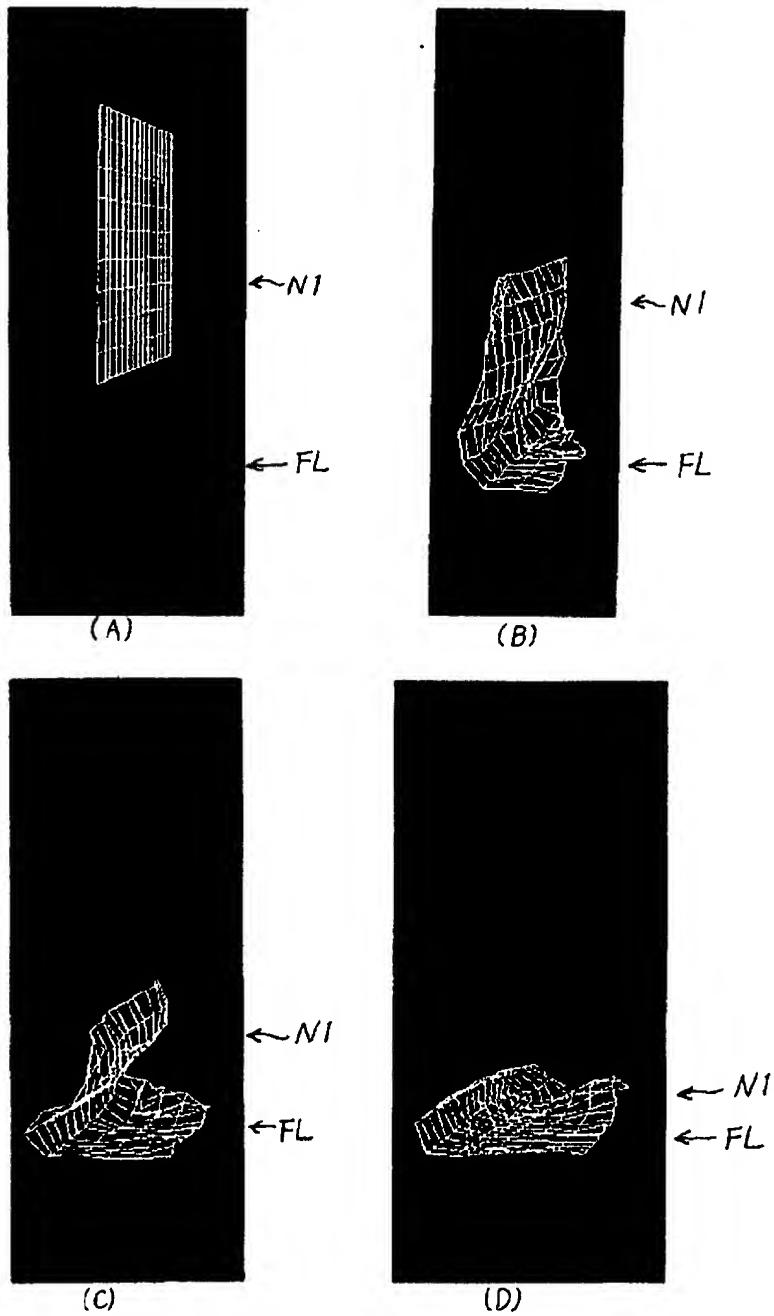


[FIG 2] FIG 2: Configuration of the Generated Animation Data
D11 ... environment data
21 ... environment data memory
22 ... linked equation calculating device
23 ... format converting device

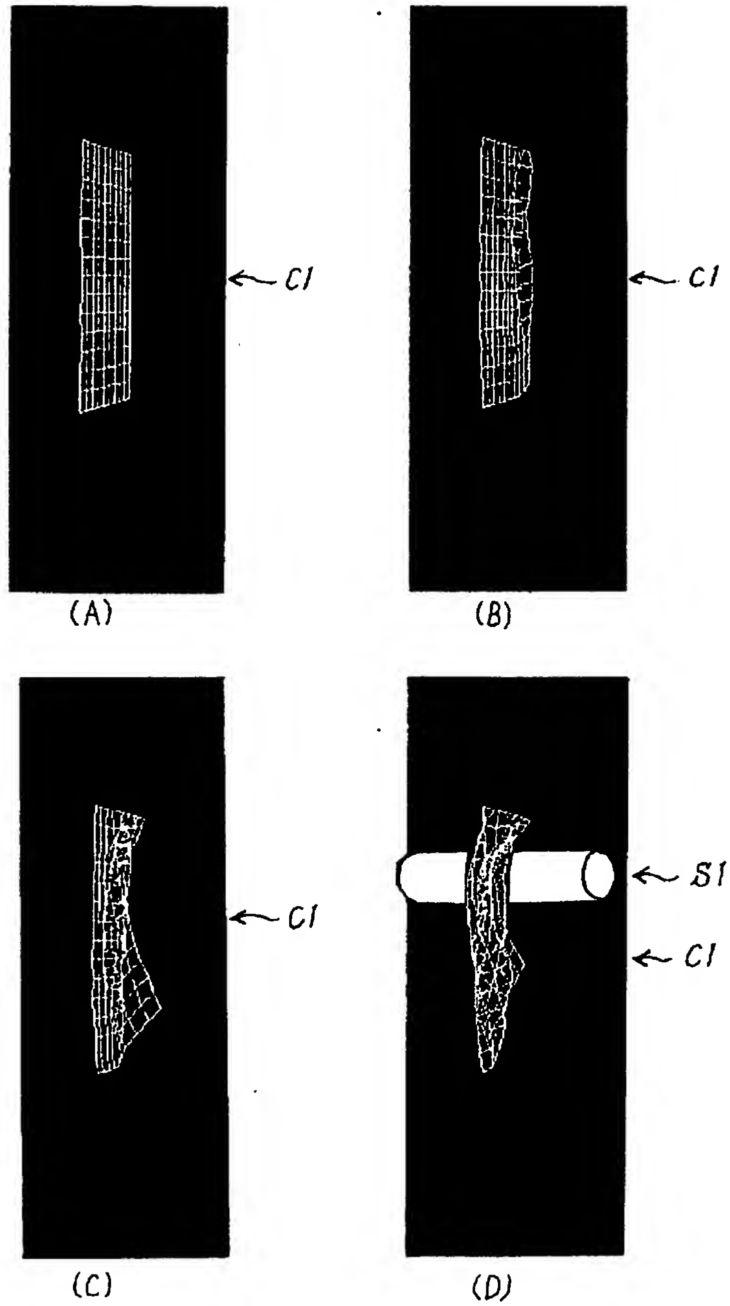
[FIG 3] FIG 3: Display Model



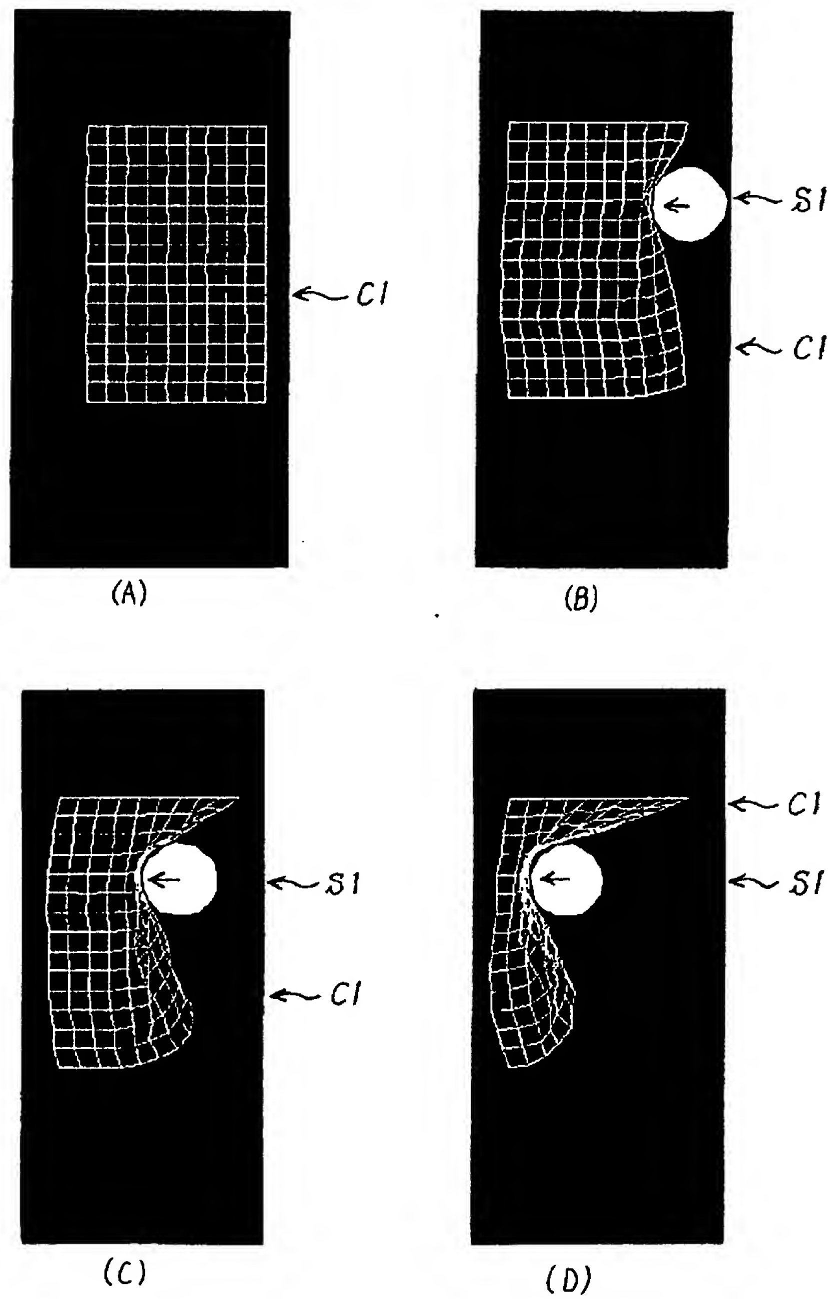
[FIG 5] FIG 5: Animation Generating Method
SP0 ... Start
SP1 ... Select sample point
SP2 ... Derive forces acting on sample point (F = Fs + Fh + Fd + Fg + Fv)
SP3 ... Derive new coordinates for sample point by solving differential equation containing F
SP4 ... Add minute random-number vector to new coordinates
SP5 ... End of processing for all sample points?
SP6 ... End



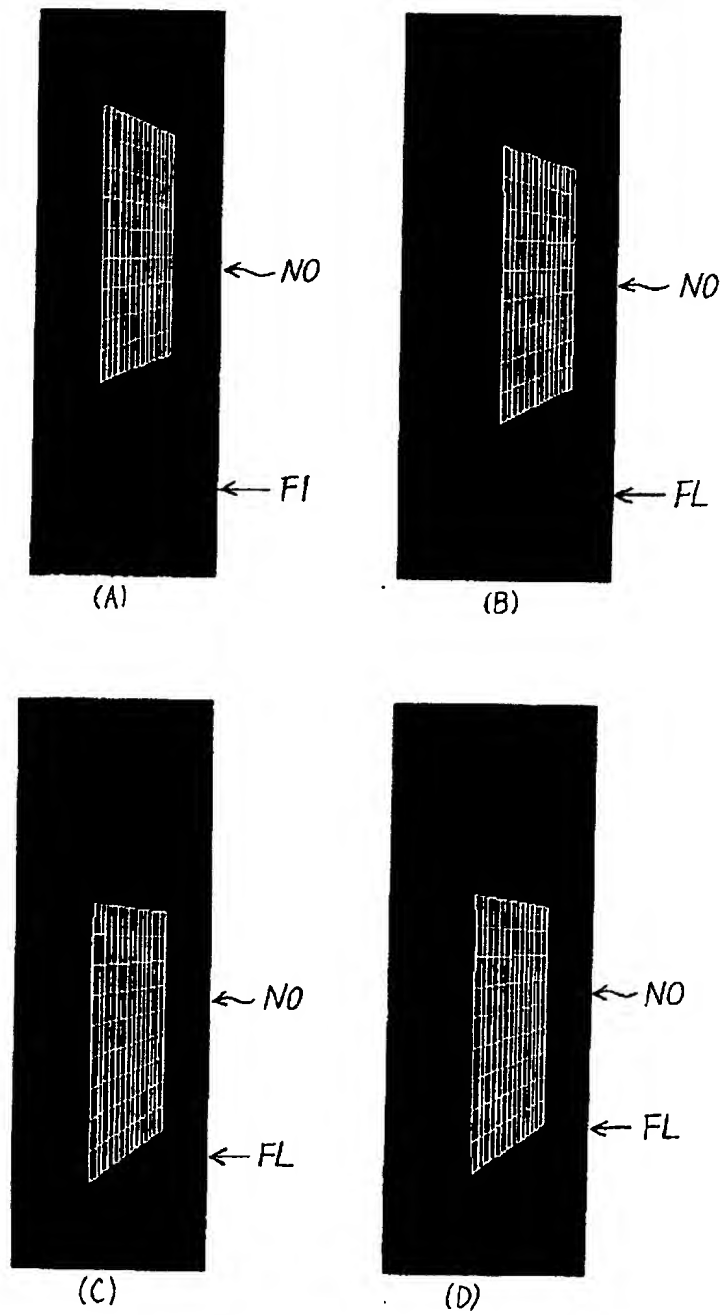
[FIG 6] FIG 6: Animation of "Cloth" in Working Example



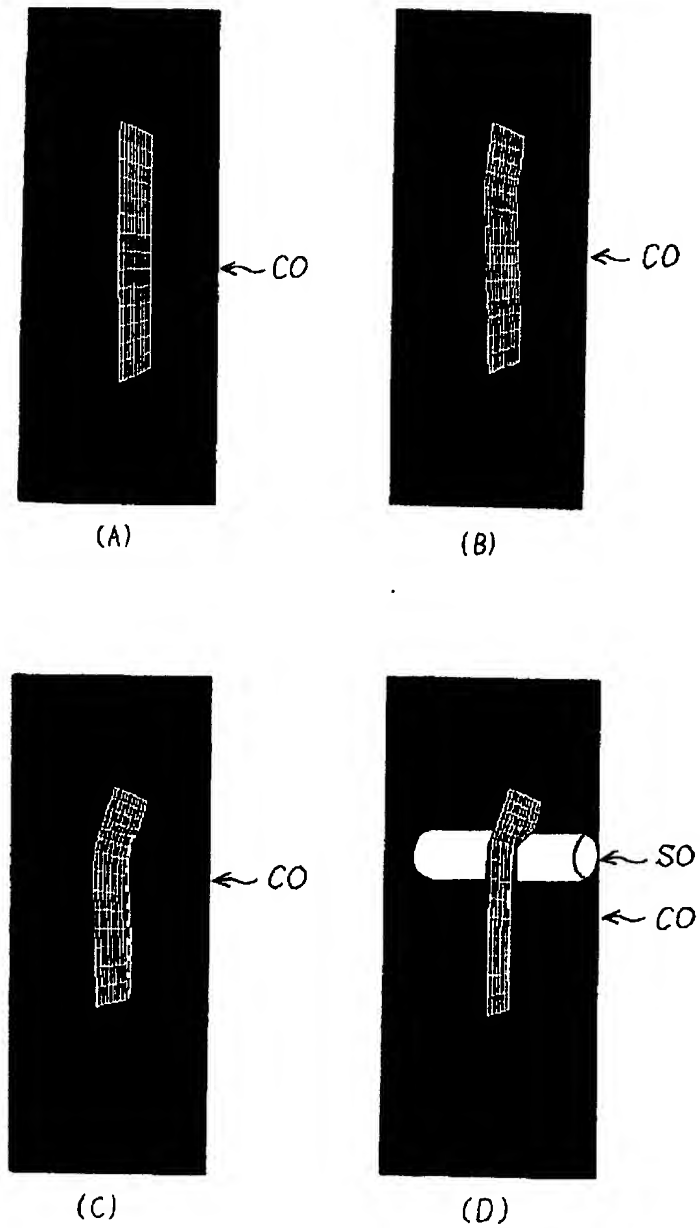
[FIG 7] FIG 7: Animation of "Curtain" in Working Example (1)



[FIG 8] FIG 8: Animation of "Curtain" in Working Example (2)



[FIG 10] FIG 10: Animation of "Cloth" in Prior Art



[FIG 11] FIG 11: Animation of "Curtain" in Prior Art